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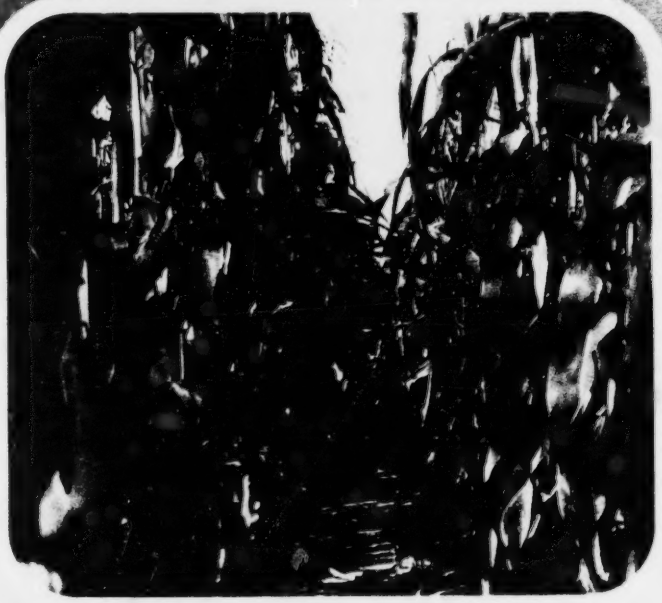
Field Corn Production in Manitoba



MANITOBA CORN COMMITTEE

MANITOBA
AGRICULTURE

FIELD CORN IN MANITOBA

Manitoba Corn Committee

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INTRODUCTION

It is recorded that grain corn was first grown in Southwestern Manitoba just over 100 years ago. As seed stocks of the strains involved were being grown and improved by farmers in the area during the first two decades of this century, it can be presumed that corn has been grown continuously since that time. The varieties grown, although very early maturing, were low yielding and of poor plant type. Improved varieties with moderately early maturity were used widely for forage production, but stable production of grain corn at a competitive level with alternative crops was not achieved until the introduction of early maturing hybrids.

The first hybrids were introduced from the United States in 1940. They performed well in the most favourable years but were not sufficiently early to produce ripe grain consistently. The Morden Research Station introduced hybrids, Morden 74 and Morden 77 in 1950. These were followed by yet earlier hybrids, Morden 88 and Morden 67, and a number of improved early hybrids have been released to the seed trade from the Manitoba breeding programs in recent years. These, along with a number of early-maturing and otherwise desirable hybrids introduced by private breeders, have made the production of grain corn a relatively reliable, economically sound enterprise in areas of the province with adequate Heat Unit accumulation. The improvement in hybrids has also been of value in raising the quality and quantity of corn for silage.

The production of grain corn in Manitoba has increased very dramatically in recent years. During the period 1970-1977 grain corn production gradually increased to 9,700 ha (24,000 ac), dramatically increasing to 80 000 hectares (200,000 acres) during the five year period of 1978-1982. Earlier maturing, higher yielding hybrids contributed substantially to the reliability of producing grain corn in Manitoba. The 432 000 tonne (17,000,000 bu) crop produced in 1981 exceeded the market requirement for Western Canada, initiating movement of grain corn into offshore markets.

The area devoted to silage production has shown a more gradual increase, reaching 30 000 hectares (75,000 acres) in 1980. In the form of silage, the combination of high yield and nutritive value make corn ideally suited to provide an economical feed for cattle.

The use of improved hybrids, adequate use of fertilizer, appropriate plant populations, and the economical use of herbicides all have contributed to reduction of risks and increased yields. Improvements in machinery have in effect, revolutionized methods of growing, harvesting and subsequent handling of the crop, contributing much to the timeliness of operations and reduction of labour costs in producing crops of high quality.

Temperature is the most critical factor limiting corn grown in Manitoba. Day temperatures of 25 to 30°C (77 to 86°F) and cool nights ranging down to 15°C (59°F) are ideal temperatures for growth and development of corn. Such temperatures, although common in midsummer in Manitoba, are rare in the first and last months of the growing season. The length of the frost-free period in a region is a factor in producing mature corn, but is not a reliable measure of the suitability of an area to the crop. This is partly because corn can recover almost completely from spring frosts which freeze off the leaves above ground, whereas fall frosts kill the plants stopping grain development. On the other hand, mild fall frosts which kill only the leaves may not entirely halt filling of the grain.

The total amount of heat available to the crop in excess of the 10°C (50°F) minimum for growth is a more reliable index of area suitability. A formula has been devised which expressed the heat units available in a region, and this can be related to the heat unit requirements of hybrids. In general, at least 2,100 heat units are required to produce quality silage and 2,300 heat units for ripe grain, using present-day hybrids. It is known that the heat units required to mature a corn crop are modified by factors such as soil type, soil moisture, humidity, soil nutrients, slope, elevation and shelter.

The heat unit map (Fig. 1) is an effective guide in making decisions on the selection of hybrids and feasibility of growing corn in a particular area.

Figs. 2 and 3 provide information on heat unit accumulation throughout Manitoba when a 25 percent risk (i.e. one year in 4 you would expect the seasonal total to be less than that shown on the map) and a 10 percent risk (one year in ten) respectively, are taken into account.

Information on climate, based on long-term weather records, is provided in Table 1. It can be used as a guide to the suitability of various areas of the province for corn production. The data is most effective when due consideration is given to soil type and the other factors important in corn adaptation. For example, although the data on Gimli, Winnipeg, and Steinbach are relatively favourable in all respects, it is known from actual tests that production of grain corn in these regions must be confined to limited areas of medium to coarse-textured, well drained soils.

The heaviest water use for corn occurs over a period of about three weeks, starting about 10 days before silking. Daytime temperatures, amount of sunshine and humidity influence the effectiveness of rainfall received by the crop. High temperature and low humidity promote water evaporation from both the plants and the soil. Some adjustment in plant populations can be made at time of seeding in areas known to have a limited moisture supply. While densities of 50 000 to 60 000 plants per hectare (22,000 to 24,000 plants per acre) have been shown to give best results in the Morden-Carman area over a period of years, lower populations may be desirable in areas where moisture stress occurs frequently.

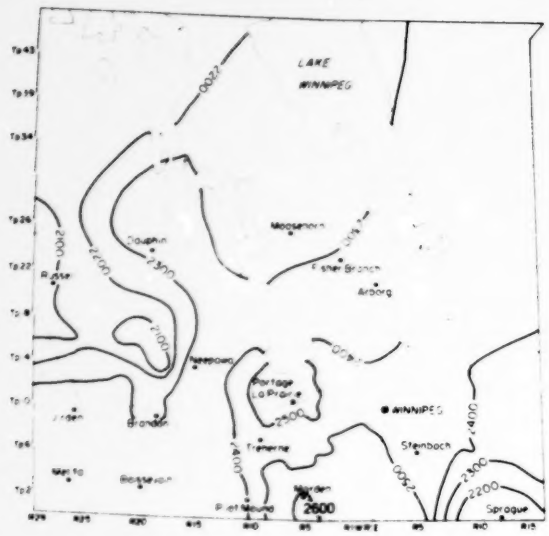


Fig. 1 Average corn heat unit accumulation.

Corn heat units are calculated for each day from planting to the date of the first frost at −2°C (28°F) in autumn. Daily accumulations are summed to give a seasonal total. The map shown here is an average seasonal accumulation.

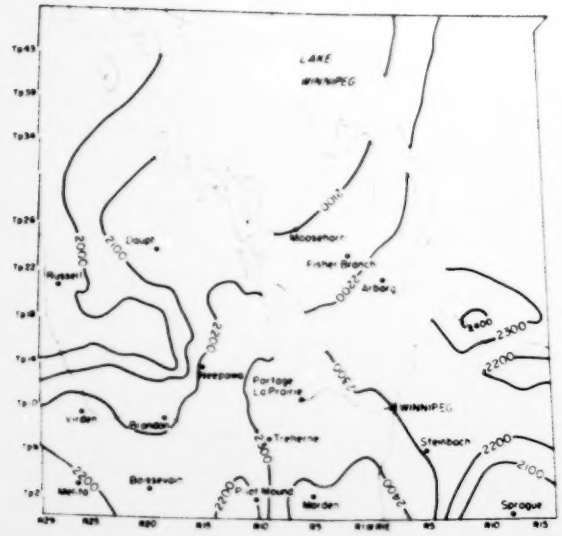


Fig. 2 25 Percent Risk Corn Heat Unit Accumulation

Calculations for this map are similar to that for the average corn heat unit accumulation. This map shows corn heat accumulation for a 25 percent risk. In other words, one year out of four the seasonal total can be less than that shown on the map, while three years out of four it would be more than that shown on the map.

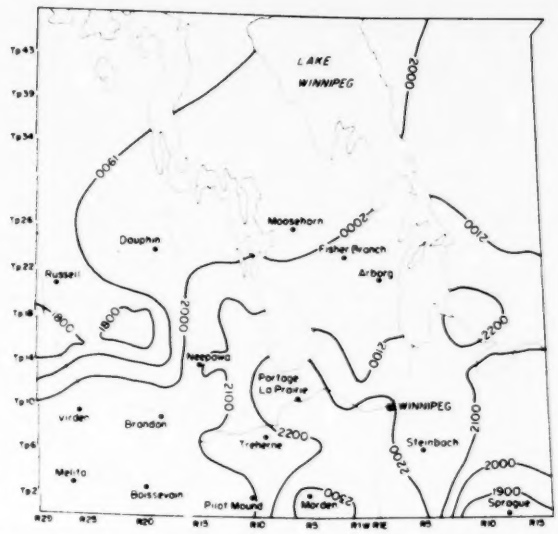


Fig. 3 10 Percent Risk Corn Heat Unit Accumulation

Calculations for this map are similar to those for the average corn heat unit accumulation. This map shows corn heat units accumulations for a 10 percent risk, in other words, one year in 10 one would expect the seasonal total to be less than that shown on the map, while nine years out of 10 it would be more than that shown on the map.

PLACE OF CORN IN ROTATION

Corn fits in well with other crops, whether preceding or following a crop in a cropping system. Corn forms a valuable component in continuous cropping systems.

An important consideration in the placing of corn in a crop sequence is the effect of herbicides such as Treflan which may have been used on the previous year's crop. Treflan can be carried over to the extent where corn is severely stunted, delayed in maturity and yield is reduced.

Continuous corn works well in fields where annual weeds and perennials such as quackgrass constitute the only problem. These weeds are easily controlled by the use of atrazine, Eradicane and other herbicides. However, if milkweed and Canada thistle are problems, it may be necessary to spot spray those patches with special herbicides or use the black summerfallow method to destroy them. Proso millet has also become a serious problem in some corn fields. Eradicane will destroy the germinating weeds. But, since Proso millet also germinates in midsummer, long after the eradicane has disappeared, it provides serious competition in the latter half of the growing season. This can result in severe yield losses. An infestation with Proso millet may force a grower into a crop rotation, destroying Proso millet by the use of other herbicides. No serious build up of disease or insects has resulted in corn fields having continuous production over the last 15 or 20 years. Yields have been at least as good as or better than in fields where crop rotation has been practiced.

Table 1
Frost Risk and Heat Units at Manitoba Points

	Last spring frost*		First autumn frost*		Corn heat units	
	Ave.	1 year in 4	Ave.	1 year in 4	Ave.	1 year in 4
Altona	M.18	M.27	S.19	S.13	2594	2444
Baldur	M.24	J. 2	S.16	S. 9	2369	2220
Beausejour	M.19	M.27	S.23	S. 7	2463	2303
Bede	M.22	M.30	S.14	S. 6	2378	2254
Birtle	M.27	J. 5	S. 3	A.22	2094	1906
Bissett	M.23	M.31	S.15	S. 2	2433	2266
Boissevain	M.22	M.31	S.19	S.11	2393	2235
Brandon	M.31	J. 8	S.11	S. 5	2285	2166
Camp Shilo	M.26	J. 3	S.16	S. 8	2440	2263
Carberry	M.23	J. 1	S.18	S.10	2364	2208
Cypress River	M.25	J. 2	S.17	S.11	2397	2259
Dauphin	M.28	J. 5	S.17	S. 9	2314	2137
Deerwood	M.22	M.29	S.24	S.17	2525	2344
Deloraine	M.27	J. 3	S.14	A.30	2369	2209
Emerson	M.22	M.30	S.17	S.10	2579	2416
Eriksdale	M.27	J. 8	S. 9	S. 2	2315	2184
Gimli	M.22	M.29	S.23	S.17	2360	2217
Grass River	M.24	J. 1	S.13	S. 6	2330	2211
Graysville	M.23	J.30	S.17	S.11	2434	2302
Great Falls	M.20	M.27	S.27	S.20	2563	2407
Hamiota	M.25	J. 3	S.11	S. 1	2255	2121
Indian Bay	M.27	J. 4	S.16	S. 9	2359	2206
Melita	M.31	J. 8	S.12	S. 7	2284	2153
Minnedosa	J. 3	J.10	S. 7	A.28	2073	1949
Moosehorn	J. 5	J.13	S.10	S. 2	2253	2084
Morden	M.21	M.28	S.22	S.17	2627	2481
Morris	M.22	M.30	S.20	S.14	2593	2414
Neepawa	M.20	M.28	S.21	S.16	2373	2224
Ninette	M.29	J. 5	S.13	S. 6	2391	2241
Pierson	M.24	J. 2	S.12	S. 4	2295	2136
Pilot Mound	M.19	M.27	S.17	S.10	2323	2183
Pinawa	M.29	J. 6	S.15	S. 3	2330	2192
Portage	M.19	M.23	S.26	S.16	2573	2415
Reston	M.22	M.30	S.16	S. 9	2343	2208
Rivers	M.24	M.31	S.16	S. 9	2329	2178
Roland	M.20	M.29	S.18	S.12	2501	2352
Rossburn	M.24	J. 1	S.15	S. 8	2197	2041
Russell	M.29	J. 6	S.10	A.31	2074	1937
Selkirk	M.22	M.31	S.23	S.18	2421	2272
Seven Sisters	M.23	M.30	S.20	S.12	2428	2257
Souris	M.29	J. 6	S.13	S. 6	2328	2201
Sprague	J. 3	J.11	A.30	A.16	2147	2000
Steinbach	M.24	J. 3	S.17	S.12	2457	2293
Stonewall	M.23	M.31	S.22	S.16	2397	2241
Strathclair	M.24	J. 2	A.31	A.10	2088	1904
Swan River	M.27	J. 3	S.12	S. 1	2129	1990
Virden	M.21	M.28	S.17	S.11	2372	2227
Waskada	M.27	J. 5	S. 8	A.29	2340	2181
Winnipeg	M.25	J. 3	S.21	S.15	2483	2341

Abbreviations: M = May; J = June; A = August; S = September.
*Frost at 0°C.

The use of atrazine as a herbicide in corn originally gave rise to the practice of continuous corn (monoculture). Atrazine carries over to the following season and may seriously damage crops following corn in rotation. The most resistant crops to residual atrazine are flax and peas. (See page 9 for further information.)

FACTORS IN CHOOSING A HYBRID

A fairly wide range of hybrids are currently adapted for use in Manitoba.

Although each hybrid may excel in certain characteristics, none has yet been found which consistently excels in all respects. Comparisons can be made on the farm among several hybrids, and the best suited chosen for the main crop the following year. Because conditions vary widely from year to year, it is wise to grow three or four hybrids, preferably representing a range in maturity, to avoid a major loss should one of the hybrids be adversely affected by unusual conditions occurring in a specific year. Established preferences should be reviewed year by year as new hybrids reach the market.

Choice of Grain Hybrids

The most important characteristics of a hybrid for grain production are early maturity, high yielding ability, and resistance to lodging and stalk breakage. Fall frost damage can generally be avoided by choosing hybrids with a heat unit rating no greater than the heat unit accumulation indicated for the growing region. Corn frozen before maturity produces grain of inferior quality, and requiring additional expenditures to dry to a level safe for storage.

Stalk strength is important as mechanical pickers often miss ears on lodged or broken plants. Most breakage results from weakening of the stalk by stalk-rot or by corn borer infestation. Both tend to increase as the proportion of land devoted to corn increases. Stalk strength, resistance to root lodging, and resistance to smut are given major consideration in breeding programs. Hybrids are rated for standability to enable the grower to give this factor due consideration in choosing a hybrid.

Choice of Silage Hybrids

Yield, maturity and lodging resistance are important considerations in choosing a hybrid for silage making. Corn reaching the dough stage, the time when most of the kernels are dented or glazed, makes the best silage. At this stage the whole plant contains 65 to 70 percent moisture. The highest yielding hybrid which generally reaches this stage before frost damage occurs is the best one to select. It is a common error to choose late-maturing hybrids which look attractive due to vigorous growth characteristics. Good quality silage requires that grain formation will be well advanced by harvest time. The least amount of trouble from freezing and spoilage occurs with silage made at the proper moisture level.

SOILS AND FERTILIZERS

Well-drained sandy loam to clay loam soils are best suited for corn production. Corn can also be satisfactorily grown on clay soils with good internal and surface drainage. Weed control by cultural methods on clay soils may pose a problem because of inaccessibility in periods of excessive rainfall. Soils coarser in texture than the sandy loams, having adequate fertility and moisture levels, produce satisfactory corn yields. Poorly drained and saline soils, regardless of texture or climatic zone, are not recommended for corn production.

Where adapted, corn has a high yield potential. It will produce more than other species in total yield of grain and stover. A large quantity of nutrients are required to grow the crop and may be removed with the harvest. For example, a crop yielding 5.0 tonne grain per hectare (80 bu/acre) removes about 72 kilograms per hectare N (64 lb/acre), 15 kilograms per hectare P_2O_5 (13 lb/acre), and 50 kilograms per hectare K_2O (45 lb/acre) from the soil. If the crop is used as silage or stover harvested for feed, a further 64 kilograms per hectare P_2O_5 (9 lb/acre) and 52 kilograms per hectare K_2O (46 lb/acre) would be removed.

Adequate fertility is an essential step for profitable crop production (See Table 2). The regular use of a reliable soil testing service is essential to plan a profitable, accurate fertilization program.

Most corn growers need to consider only nitrogen, phosphorus and potassium in their fertility program. Though much work is underway on the role of micronutrients, no benefits have yet been documented. In any case, specific information is necessary before the use of micronutrients is recommended as they may produce a yield reduction, as a result of the creation of a nutrient imbalance.

The best response to nitgrogen, phosphorus and potassium is from band application at the time of seeding. The total amount of fertilizer material side banded should not exceed 340 kilograms per hectare (303 lb/acre). Nitrogen requirements not side banded at the time of seeding should be side-dressed before the plants are 15 cm (6 in.) high.

Since corn has a very high requirement of nitrogen, applications of 75 to 150 kilograms per hectare (67 to 134 lb/acre) are required on stubble land to obtain grain yields of 5,000 kilograms per hectare 80 bu/acre). Climatic conditions such as lack of water or low temperature may determine the maximum yield attainable. Application of more than 150 kilograms per hectare (134 lb/acre) of N usually does not result in added benefits. Under continuous corn, the higher amounts of fertilizer application may result in excessive nutrient levels. Hence, a soil test is strongly recommended to monitor nutrient conditions.

Phosphorus and potassium should be applied as a side-band application, preferably 5 to 8 centimetres (2 to 3 in.) from the row at time of seeding.

Nitrogen may be applied in three ways: (1) mixed with the phosphorus and potassium and applied side-band at time of seeding (total amount of fertili-

zer material sidebanded should not exceed 340 kilograms per hectare (303 lb/acre); (2) applied as a sidedressing when the corn is about 15 cm (6 in.) in height; (3) applied broadcast. Broadcasting nitrogen is somewhat less efficient than sidebanding. The average relative value of times and methods of application, calculated for annual crops such as the cereals, also apply for time and methods of nitrogen application for corn. These are:

Time and Method	Relative Value
Spring broadcast	100
Spring banded	120
Fall broadcast	82
Fall banded	93

Sulphur fertilizers may be added either with other nutrients or separately. The sulphur fertilizer recommendations are based on sulphur being applied in the sulfate ($SO_4=$) form. Sulphur in the elemental form, as it occurs in some high analysis sulphur products such as flaked or prilled elemental sulphur (99 percent S), flowers of sulphur (99 percent S) or granular sulphur (90 percent S) is not available to plants until oxidized. Oxidation of sulphur requires time, depends upon soil temperature, soil moisture, size of sulphur granule and the rate at which granules break down in the soil. Recent research shows sulphur from these products does not become available in sufficient quantities to meet crop requirements in the year of application. It is not advisable to apply these products on soils low in available sulphur where the crops grown would require the applied sulphur that year.

Ammonium thiosulphate 12-0-0(26), is a liquid formulation containing 26 percent sulphur by weight. One-half of the sulphur converts into the readily available sulphate form and the remainder into finely divided elemental sulphur. This product can be applied to supply sulphur at the rate recommended for sulphate sulpur.

SEED BED PREPARATION

Seed-bed preparation is a critical initial step for the successful establishment of a corn field. It is the foundation to successful production, including necessary weed control.

It is very important to obtain uniform and early emergence of the corn crop. This can be achieved with a good, firm, mellow seed-bed, which possesses good tilth and holds moisture near the soil surface. Germination of corn is very temperature-dependent, not occurring when soil temperatures drop below 10°C (50°F). Optimum germination and emergence occurs when the soil temperature at a depth of 10 centimetres (4 in.) reaches 12 to 15°C (54 to 59°F), usually during the third and fourth week of May in Manitoba.

Tillage practices vary with soil type and condition. In general, most primary tillage can be performed in the fall. Erosion may be reduced through mulching and/or leaving the surface rough. Since new corn planters are designed to operate without plugging or missing, burial of crop residue is less important than it was in the past.

Pre-plant incorporation is usually practiced, combining spring tillage with herbicide application. Care must be exercised to avoid excess moisture loss from the seed-bed.

Different methods have been used immediately following the combine to breakup and spread the

TABLE 2
General Fertilizer Recommendation

Corn grown on	Nitrogen (N) (1) kg/ha	Nitrogen (N) (1) lbs/ acre	Phosphate (P_2O_5) kg/ha	Phosphate (P_2O_5) lbs/ acre	Potash (K_2O) kg/ha	Potash (K_2O) lbs/ acre	Sulphur (S) kg/ha	Sulphur (S) lbs/ acre
Fallow or legume breaking (2)	0-30	0-27	30-45	27-40	(3)	(3)	(4)	(4)
Grass and grass-legume breaking (2)	30-75	27-67	30-45	27-40	(3)	(3)	(4)	(4)
Stubble	75-150	67-134	30-45	27-40	(3)	(3)	(4)	(4)

(1) Rates are based on granular nitrogen applied broadcast at or near seeding time.

(2) Refers to breaking after first cut of forage.

(3) Sands, sandy loam and organic soils are frequently low in available potassium. On these soils apply 30 to 110 kilograms per hectare (27 to 98 lb/acre) of potash (K_2O).

(4) Twenty kilograms per hectare (18 lb/acre) of sulphur (S) are recommended on well-drained sandy soils.

stover evenly. Rotary flails, mowers and discs followed by a plow or a cultivator are normally used in the fall. In some instances, the residue is used for feed. Some grain producers use a flail forage harvester system to remove most of the stover, while others have designed chaff and husk savers. Some growers use stover as a fuel for artificially drying the grain.

PLANTING

Date

The optimum seeding time is the first two weeks in May. Research has shown that a yield reduction of 62 kilograms per hectare per day (1 bu/acre/day) can be expected when the date of seeding is delayed beyond mid-May.

All commercial seed sold in Canada must have a warm temperature germination test. Most companies also use a cold germination test, simulating field conditions. In addition, seed should be drill box treated with an insecticide for prevention of insect and disease problems.

Planting earlier than the first week in May may be warranted when an open spring occurs. Under these circumstances a 5 percent increase in plant population would be advised to allow for losses that may occur due to climatic and biological factors.

Corn is able to tolerate spring frosts fairly successfully because the growing point is below the soil surface during the seedling stage. Stands can be reduced by frost or other facts by as much as 5 percent without an appreciable loss in yield. The recommendation of adding 5 percent population to a very early spring planting should compensate for freezing losses.

An early date of planting is important for maximum yield, top quality (test weight) and low percent kernel moisture in grain corn at harvest. In silage, while actual dry matter yield is not affected, the seeding date influences the maturity. Since maturity influences fermentation and thus silage quality, planting date is crucial for optimum silage quality.

The main reason for the effect of the planting date on final grain yield is the soil moisture deficit that normally occurs at silking. Our rainfall and evapotranspiration pattern on the prairies results in an average moisture deficit of 10 centimetres (4 in.) on July 31 and 20 centimetres (8 in.) on August 31. Early planting, resulting in early emergence, allows silking to occur during the best possible moisture conditions. An additional five to six weeks are normally required for grain to mature following anthesis, which for early hybrids is reached in the last week in August. After grain maturity, fall frosts are no longer a significant factor.

For silage, the conditions are similar. The amount of grain in the silage is dependent on silking and pollination occurring with a minimum moisture stress. Early planting produces the best quality silage.

Depth

Seed corn should be placed in close contact with warm, moist soil, with enough covering for reasonable protection against birds, rodents, and surface drying. Quick germination and emergence means less trouble from soil-borne diseases, insects and encrusted soil. Under settled soil 2.5 centimetres (1 in.) is shallow planting; 7.5 centimetres (3 in.) is deep. The depth of the root system is not influenced by planting depth.

Rate

Many factors affect plant population including soil type, fertility, drainage, planting dates, location, and the purpose of the crop. For grain, a density of 45 000 to 60 000 plants per hectare (18,000 to 24,000/acre) is recommended, while for silage, the stand should be increased to 55 000 to 70 000 plants per hectare (22,000 to 28,000 plants/acre).

The only sure method of obtaining the desired seeding rate is to calibrate the planter at planting speed, using the current year's seed. Each seed produces just one stalk, which in turn usually produces a single ear. The grain yield of each plant is changed only slightly by moderate changes in planting rates. However, excessive populations of over 60 000 plants per hectare (24,000 plants/acre) may result in a higher percentage of barren plants or poorly developed ears. Therefore, the greatest increase in grain yield can be obtained by ensuring that the current population is selected and uniformly distributed in the field.

The following table will serve as a guide in calibrating a planter.

TABLE 3
Seed Spacing Necessary to Give the Required Plant Population Assuming an 85% Plant Survival

Row Width cm (inches)	Plants per ha (acre) 45,000 (18,000)	Plants per ha (acre) 49,000 (20,000)	Plants per ha (acre) 55,000 (22,000)	Plants per ha (acre) 60,000 (24,000)	Plants per ha (acre) 69,000 (28,000)
76 (30)	25 (9.9)	23 (8.9)	20 (8.1)	19 (7.4)	16 (6.3)
91 (36)	21 (8.2)	19 (7.4)	17 (6.7)	16 (6.2)	14 (5.3)
97 (38)	20 (7.8)	18 (7.0)	16 (6.4)	15 (5.8)	13 (5.0)
102 (40)	19 (7.4)	17 (6.7)	15 (6.1)	14 (5.6)	12 (4.8)

The higher rates are appropriate for land with good structure, high water holding capacity and good management. On poorly drained soils of low fertility, lower populations are advised. On many farms, different fields may require different populations for optimum production.

Row Spacing

Growers are using row spacing ranging from 76 to 102 centimetres (30 to 40 in.). However, experiments in Canada and the U.S.A. indicate very little difference in grain yield for corn grown at this range. The small differences found favoured the narrower spacings when the same populations were used. Therefore, it is advisable to select a row spacing that can be handled with the available equipment, making field operations such as planting, cultivating and harvesting easy.

The use of one common row spacing by all producers, would facilitate the exchange of equipment between growers, and make it easier for custom operators. The 91 centimetres (36 in.) row spacings are most practical. Field operations become more difficult if row spacing is narrower. There is no yield advantage to wider spacings.

Planters

An efficient seeding operation involves the use of proper equipment. Doing this today means the use of a corn planter, not a grain drill. They come equipped with dry or liquid fertilizer attachments which place the fertilizer in a band slightly below and to the side of the seed, where it does the most good. Planters come in many sizes ranging from four to 24 rows. Plateless planters have largely replaced plate planters on the market, doing a better job of planting seed of variable size.

Kernels vary widely in shape and size. Use only properly graded seed with plate planters. Seed is graded into small, medium and large of both flats and rounds. A wide variety of planter plates are available for all modern corn planters. Plates must be selected which are appropriate to the seed being planted, so the corn will be planted accurately and uniformly without seed damage.

The rate of planting will be determined by the choice of appropriate planter plates, drive sprockets, and the setting of the variable drop-shifting lever. Follow the directions that come with the planter.

The accuracy of the planter can be tested by raising the runners and planting on the edge of the field or in the farmyard. Determining the particular plate required is done by fitting kernels in plate cells and selecting a plate with cells which hold only one kernel. Each lot of seed must be checked.

A driving speed of about 4 kilometres per hour (2.5 mph) should not be exceeded for plate-type planters in order to provide maximum accuracy of spacing. Faster speeds can also damage the seed. Maximum speed at which plateless planters should be operated is 5 kilometres per hour (3 mph).

WEED CONTROL IN CORN

Fig. 4 Weeds compete strongly with corn causing severe damage.

Fig. 5 Using a rotary hoe helps control young weeds after emergence.

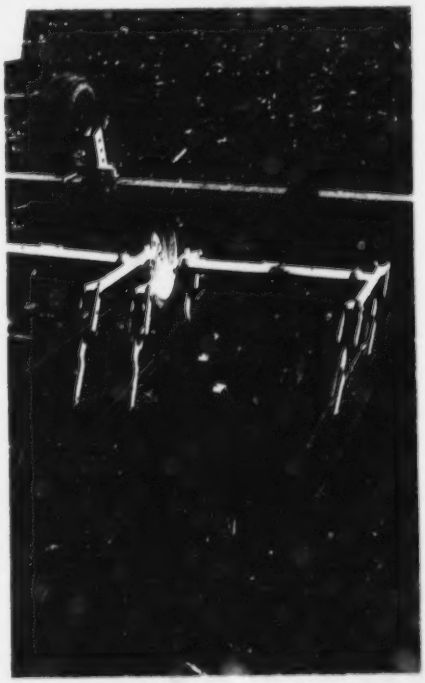


Fig. 6 Row crop cultivation used in corn.

Fig. 7 Typical 2,4-D injury symptom shows distorted adventituous brace roots.

Corn is a poor competitor with weeds, particularly in the early stages of seedling establishment (Fig. 4). To ensure maximum production it is imperative to integrage both cultural and chemical control methods to minimize losses due to weeds.

Weeds compete strongly with corn causing severe yield losses.

Inter-row cultivation

Effective control of young annual weeds after the corn has emerged, is accomplished by using a rotary hoe (Fig. 5) between the rows. Do the initial cultivation as soon as enough corn plants have emerged to clearly identify the row. Set the rotary hoe to throw the soil away from the corn row. Once weed seedlings have emerged and the corn has reached sufficient height to prevent burial, set the rotary hoe to throw the soil back into the corn row burying the weed seedlings. In this final cultivation, care must be taken to prevent excessive covering of the exposed corn plant.

When the corn is more than 15 centimetres (6 in.) high, use a row-crop cultivator (Fig. 6). At this stage, cultivation should be 5 centimetres (2 in.) deep and fairly close to the plants. Do not cover the corn plants with soil. As growth continues, roots spread out rapidly so cultivation must be further from the plants and shallower to avoid cutting off feeder roots. Cultivation should be stopped when the plants are 75 centimetres (30 in.) tall.

Since corn is a shallow rooted plant, cultivating too deeply or too close to the stalks can damage the roots and may result in stalk breakage later in the season.

Chemical Control Methods

The choice of herbicides* to use in corn depends on the rotational practice being followed. Some products are primarily restricted to continuous corn production since they leave residues in the soil that can damage sensitive crops for several years after application. This is particularly true for the triazine family of herbicides. Atrazine, simazine and cyanazine are all triazine herbicides marketed under different trade names. Atrazine and simazine, especially, can persist in the soil for several years. Cyanazine, generally less persistent, still carries over in some years under western Canadian conditions. The residual action of the triazine herbicides generally provides for effective season-long control of weeds in continuous corn. But it can impose severe restrictions on the choice of crops grown in rotation. Whenever there is any doubt about whether or not the land will remain committed to continuous corn production, use non-residual herbicides.

Continuous corn production

One of the most commonly used herbicides in continuous corn is atrazine. This chemical is absorbed by the roots and leaves of small seedling weeds. It kills the weeds by blocking the plants' ability to utilize sunlight to manufacture sugars and other foodstuffs in the leaves.

The preferred method of applying atrazine is as a post-emergence spray in combination with an oil or oil concentrate in a band application over the emerged corn seedlings. In some commercial formulations the oil concentrate is already included, but in others it must be added separately. Use only oils or oil concentrates specifically recommended for the product being applied and in strict accordance with label instructions.

Atrazine and other related triazine herbicides control a broad spectrum of both annual and grassy weeds. Best results are usually obtained when the weed seedlings are small and moisture conditions are good. Rainfall amounting to at least 1 centimetre (⅜ in.) during the week after spraying will wash some of the chemical into the root zone of the germinating weeds, generally improving the activity of the chemical.

Under dry soil conditions, control of grassy weeds, particularly green foxtail, is sometimes inconsistent. To ensure the best possible control of green foxtail it is imperative to apply atrazine before the weed reaches the three- to four-leaf stage. Foxtail can be fairly consistently controlled with products such as Dual, Lasso, Sutan + or Eradicane applied as pre-

*The use of brand names does not constitute endorsement or preferential recommendation of a particular product over other herbicides of similar chemical formulation.

plant incorporated treatments. These are normally incorporated into the soil prior to seeding and can be tank-mixed with atrazine for broad-spectrum weed control. Primextra is a formulated mixture containing the same active materials as in a Dual/atrazine tank mixture. Eradicane and Sutan+ must be applied to a dry soil surface and incorporated immediately after application.

On irrigated land, incorporation of some chemicals is not necessary. These products can be applied as pre-emergence treatments to the soil surface after seeding.

For a more complete list of the various weeds each of the products control and for specific instructions on how they should be applied, refer to the Guide to Chemical Weed Control published annually by Manitoba Agriculture and consult the product labels.

Corn grown in rotations with other crops

In rotational corn, grassy weeds including wild oats and foxtails can be controlled by pre-plant incorporated treatments of Eradicane. Where wild oats are not a problem, chemicals such as Dual, Lasso or Sutan+ can also be used as pre-plant incorporated treatments to control other grassy weeds, particularly green and yellow foxtail and barnyard grass. As previously mentioned, Eradicane and Sutan+ must be incorporated immediately after chemical application to prevent evaporation of the chemical and a reduction in performance.

Broadleaf weeds can be controlled in rotational corn with Banvel, or 2,4-D applied alone or as tank-mixtures or with commercial formulations such as Kilmor that contain both these active ingredients. Bromoxynil (Torch, Pardner) is also registered for use in corn for broadleaf weed control. Overall treatments of 2,4-D and Banvel can be applied safely only when the corn is less than 15 centimetres (6 in.) tall with leaves outstretched. Torch and Pardner can be applied up to the time the corn is 25 centimetres (10 in.) tall, but to ensure maximum effectiveness the weed seedlings must not be past the four-leaf stage. For corn over 15 centimetres (6 in.) tall, 2,4-D and Banvel can be applied as directed sprays between the rows, provided the sprayer is set up in such a way that none of the herbicide is sprayed onto the corn leaves. Since corn is not completely tolerant to the hormone weed killers including 2,4-D and Banvel, over-dosing the plants or applying the chemicals at later-than-recommended stages of growth can result in damage. Typical symptoms include leaf rolling and crinkling (onion-leaf) and distorted development of the adventitious brace roots (Fig. 7) causing stalk leaning and breakage.

Special considerations in a chemical control program are:

- **Crop tolerance to atrazine residues.** Among the more commonly grown crops, flax, peas and fababeans are the most tolerant of atrazine residues. Where the amount of carry-over is low, i.e., where no more than 1 kilogram per hectare (0.9 lb/acre) was applied to corn fields, these crops can be grown following corn. But, some damage can be expected, especially in the first year after the atrazine was last applied. Where higher concentrations of atrazine carry over, damage may show up two and sometimes three years after the last application of the chemical. Minimize potential soil residues by either applying atrazine as a band application over the rows, thereby reducing the total amount of product applied, or applying the chemical at lower rates in combination with other products as a registered tank mix.
- **Canada thistle.** Canada thistle will pose a serious problem if allowed to establish in corn fields. Make every effort to prevent the spread of this weed. Since thistles often emerge after the crop is well established, it may be necessary to apply chemicals like 2,4-D or Banvel as directed sprays with drop-nozzles. Split-applications of Basagran, seven to 10 days apart, will control the top-growth of Canada thistle, while being effective for patch treatments. Basagran does not translocate to the roots.
- **Proso millet.** Tame (Proso) millet is becoming a very serious weed in continuous corn fields in the Province. The weed is resistant to atrazine. High rates of Eradicane give a measure of control but results are frequently disappointing. No other corn herbicides adequately control the weed. Where proso millet becomes established it is necessary to grow corn in rotation with other crops in which chemical control is feasible.
- **Eradicane performance after repeated applications.** The level of weed control may be reduced in fields where Eradicane is used on soils treated with Eradicane or Eptam the previous year. Research results indicate that the rate of Eradicane disappearance from the soil increases with increasing use. The faster rate of disappearance allows late-germinating weeds to escape control. Possible reduction in control will be greater where Eradicane or Eptam has been used repeatedly for two or more years. Experimental results indicate that the addition of extenders to the Eradicane may prevent the enhanced rate of disappearance in fields treated repeatedly but these are not presently used commercially.
- **Treflan carryover.** Treflan residues have been known to affect corn seedling establishment. Where Treflan has been used the year previous to planting corn, the chances of some damage occurring to the corn should be considered as a possibility.

DISEASES IN CORN

Root and Stalk rot

Root and stalk rot is one of the most serious problems in corn. These diseases are generally caused by a complex of fungi and bacteria that attack plants approaching maturity. The fungi and bacteria that cause the disease are present in living and dead corn plants and can survive on corn refuse in the soil. One of the organisms called Gibberella also attacks cer

eal grains particularly barley, causing root rot. Spores of some types of the fungi causing root and stalk rot are wind-borne. Infection occurs through the roots, stalks and ears.

Infection of the corn plants results in general weakening of plants. Severely infected plants often die prematurely. Mature plants are weakened due to the fungus attacking the roots and pith of the stalks causing a breakdown of plant tissue. Infected stems often appear shredded and discoloured. Bacterial stalk rot causes stalks to collapse. Infected stem tissue is soft and mushy and often has a foul odour.

There is no chemical control for root and stalk rot. The disease can be reduced by the following practices:

controlling the plant population to eliminate an excessively high plant population which can cause stress on individual plants. Overpopulation tends to increase stalk rot and lodging.

maintaining a good soil fertility balance helps control fungal stalk rots. These rots are generally more severe when nitrogen is in excess in relation to potassium. Excess nitrogen can lead to increased lodging.

plant sound disease-free seed treated with a fungicide.

Continuous cropping of corn may be desirable for a number of reasons. If this practice is followed, the grower should watch the field for evidence of disease buildup. Where disease is becoming a problem, the field should be taken out of corn production for several years to break the life cycle of the disease organisms. Diseases are not a serious problem with corn in Manitoba now, but this situation could change with increased corn production and use of continuous cropping.

Ear and Kernel Rots

Corn is susceptible to a number of ear and kernel rots caused by fungi. Some of these rots begin in the field prior to harvest and others are associated with storage decay. Storage rots are caused principally by species of Aspergillus, Penicillium, and Fusarium fungi. Storage decay is favoured when kernel moisture content is above 15 percent and storage temperature is between 21 and 32°C (70 to 90°F). At moisture contents below 15 percent and temperatures below 10°C (50°F) the risk of storage decay is lessened. Some types of storage moulds can produce poisonous by-products called mycotoxins which are toxic when consumed by animals or man.

There are numerous types of mycotoxins such as the aflatoxins, ochratoxin A, Sterigmatocystin, zearalenone, and T-2 toxin and related trichothecenes. Ochratoxin A is the most frequently encountered mycotoxin in Manitoba. Analysis of a feed sample by chemical methods is necessary to detect presence of mycotoxins. Presence of mycotoxins in animal feeds may result in increased mortality, feed refusal, reduced productivity and depressed growth. Mycotoxins often do not produce specific clinical signs in animals that allow for a positive diagnosis of symptoms alone. To minimize mycotoxin production:

- Follow harvesting recommendations to minimize grain damage. Damaged kernels are more susceptible to storage decay than sound kernels.
- Dry corn harvested above 18 percent moisture unless it is placed in airtight storage, preserved in acid, or frozen. Corn should be dried to 14 percent moisture as quickly as possible.
- Thoroughly clean grain bins and grain, if feasible, before storage to remove soil, dust, crop debris, and cracked or broken kernels.
- Prevent insect, rodent and snowmelt inundation damage to corn in storage.
- High moisture corn can be safely stored when treated with organic acids. These acids will control mould growth after treatment but they will not generally inactivate or degrade any mycotoxins that may have been produced by fungi causing storage decay prior to the acid treatment. For further information consult the section in this manual on Harvesting and Storing Grain Corn.

Damping-off and Seedling Blight

Damping-off and seedling blight are caused by soil and seed borne fungi. These diseases are favoured by wet and cold (less than 10°C or 50°F) soils, mechanical injury to the seed coat and excessive planting depth. Pre-emergence damping-off or seed decay results in a reduced stand. The symptoms of post emergence damping-off are wilting and yellowing or chlorosis of the leaves. Rotting of the stem tissue often occurs around the soil line. Fungicidal seed treatment helps to protect the seed and seedlings from infection.

Smut and Rust

Smut and rust may occur sporadically. Modern hybrids are resistant enough to prevent serious epidemics. Corn smut appears anywhere on the plants, first as white galls which later turn black. Rust appears on the leaves in summer as reddish pustules, changing to black as the corn matures. Since smut spores live over in the soil, extending the time between corn crops on the same land will reduce the disease.

Northern Leaf Blight

Northern corn leaf blight has not been a problem in Manitoba to date but traces of it have been noted over a number of years. It is manifested by long, elliptical, grayish-green or tan spots on the leaves in August and September. When severe, the lesions cover almost the entire leaf. After the leaf tissue is killed, the fungus produces numerous spores on the surface of the lesion. The spores are wind-borne and can cause secondary infestion if the weather is warm and humid. Destruction of the functional leaf tissue causes yield reductions. The disease does not infect the kernels.

Normally, this disease is not conspicuous until sometime after tasseling. This is primarily due to the

absence of long periods of dew rather than resistance to infection. Long dew periods are more likely to occur within a corn field after the corn plants reach full foliage. If the disease becomes established within three weeks after silking, yields can be reduced as much as 50 percent. When the disease does not become severe until six or eight weeks after full silk, no significant loss in grain yield is likely to occur.

There is no chemical control for northern corn leaf blight. The fungus can overwinter on infected corn stubble, producing spores on the surface of the undecomposed corn tissues the following season. These spores are wind-borne and can cause re-infection of a corn crop grown in the same of adjacent fields. Crop rotation of at least two years between successive corn crops will help to control the disease.

INSECTS IN CORN

Fig. 8 Corn stalk borer larvae. Courtesy of Ag. Canada

Corn Stalk Borer (Helotropha reniformis)

The corn stalk borer appears to be increasing in recent years. The larvae is a brownish colour and bores into the corn plant at below surface level destroying the growing point. Infestations are present during the seedling stage and remain until about the end of June. There is some evidence that one larvae will infest several plants while completing its development.

Infestations often are present along field margins, but can occur throughout fields as well. The adult moth prefers to lay its eggs on grassy plants and the larvae move to corn plants nearby. This insect is a potentially serious pest of corn in Manitoba, however, at present there are no insecticides registered for its control.

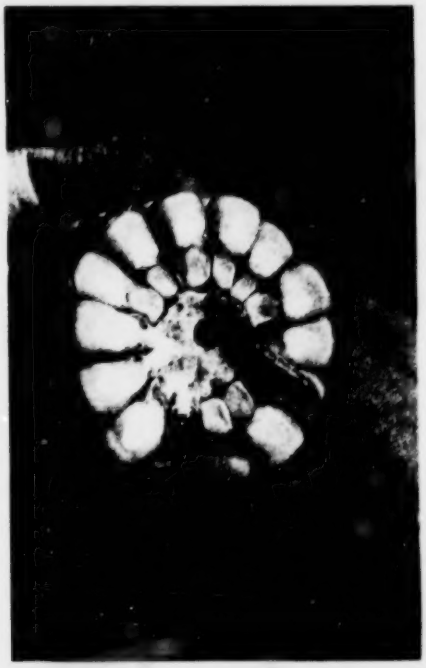


Fig. 9 European corn borer larvae. Courtesy of Chemagro Ltd

European Corn Borer (Ostrinia nubilalis)

This insect was first noticed in Manitoba about 1948. Serious localized outbreaks have occurred since that time. The adults are small moths. Eggs are laid in groups on the underside of leaves. Fully grown larvae overwinter in cocoons in old stalks left in the field.

Damage to crops is caused by the insect in the larvae stage. The larvae are almost 25 mm (1 in.) long when fully grown; the body is flesh coloured, inconspicuously marked with small, round brown dots. They may be found in all parts of the stem or ear, and sometimes feed on the leaves. Stalks may break off if heavily infested. Larvae in an ear of corn will tunnel throughout the cob. Control measures in field corn are not practical because only after the larvae have entered the plant is the damage detectable and by that time spraying is ineffective.

Cutworms

Cutworms damage crops by chewing young plants off at the soil surface. Most cutworms feed at night and most damage occurs between late May and the end of June.

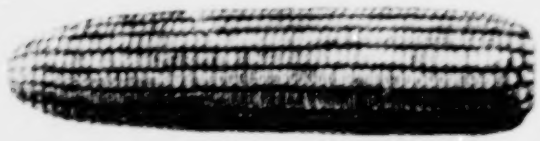
Since cutworms are most active on warm nights, best control can be obtained if spraying is done on an evening preceding a warm night. For recommended insecticides and rates of application, see Manitoba Agriculture publication Insect Control On Field Crops.

Wireworms

Wireworm larvae are reddish brown or yellow-brown hard bodied worms, up to 25 mm (1 in.) in length. They bore into seeds of corn or destroy young seedlings by damaging the stem or roots just below the soil surface.

Use commercially available wireworm seed treatments for control.

EAR SYMPTOMS OF NUTRIENT DEFICIENCIES



NORMAL EAR on adequately fertilized corn has well-filled tips and weighs about 0.3 kg (0.7 lb.)

POTASH shortage causes ears with poorly filled tips and loose chaffy kernels.

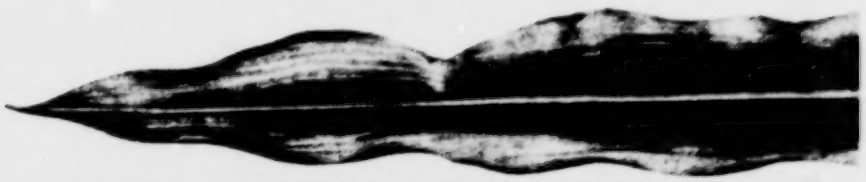
PHOSPHATE inadequacy causes small ears which are often twisted and have undeveloped kernels.

NITROGEN shortage at critical stage of growth results in small ears and poorly filled tips and low protein content.

DROUGHT delays silking and results in poor fertilization and kernel development.

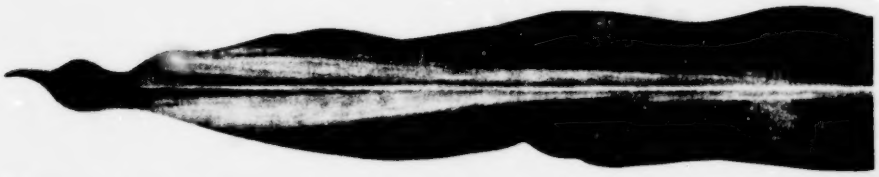
LEAF SYMPTOMS OF NUTRIENT DEFICIENCIES

HEALTHY leaves display rich dark green colour under adequate nutrition.



POTASH deficiency causes firing or drying along the tips and edges of lowest leaves.

PHOSPHATE shortage results in a reddish-purple colour in leaves, particularly in young plants.



NITROGEN deficiency causes yellowing that starts at the tips and moves along the middle of the leaf.

DROUGHT causes a greyish green colour in the plant and leaves tend to roll up.

HARVESTING AND STORING GRAIN CORN

Harvesting losses are a major problem in corn production. In Manitoba, losses of over 20 percent have been observed. Major losses occur when stalks or cobs are bent over or broken off. Since most of the losses occur at the corn header, careful operation and adjustment in this area is critical.

Grain corn harvesting may commence when the kernel moisture content reaches 30 percent. This should result in the maximum amount of harvesting near 25 percent, which is approximately the point of lowest field losses.

If the moisture content is too high, many of the kernels will rupture before breaking away from the cob, and longitudinal cob breakage may increase.

Gathering Snouts

The purpose of the snouts is to lift and direct ears and stalks into the gathering chains. Under ideal conditions the snouts can be levelled and run at or just above the ground surface. Where broken down ears or stalks are present, make full use of the floating action of snouts. Adjust the centre snout so it is just touching the ground when the gathering chains are slightly above the ground. Then position each successive snout slightly lower than the one next to it, and drive with the centre snout just touching the ground. The shoes of the other snouts should stop any digging action. This will ensure that all gathering points are floating on the ground even though the machine may tilt from side to side on uneven ground. If the soil or crop conditions cause dirt to be funnelled into the gathering chains, or cause dirt and leaves to be accumulated on the snouts, level all the snouts and operate them just above the ground. Make sure that the gathering chains are maintained slightly above the ground and the snouts are as close as possible to the ground.

CAUTION: Always lower cylinder safety stops on combine before attempting to make any adjustment on the corn head when it is in its raised position.

Stalk Rolls

The spacing between the stalk rolls should be adjusted to the stalk diameter. If the rolls are too far apart they cannot grasp the stalks firmly enough to snap the ears from them. This may cause shelling of the ears or plugging of the picking unit. If the rolls are set too closely, the stalks may be crushed and the upper part of the stalk will remain attached to the ear.

The speed of the stalk rolls are usually pre-set by the manufacturer, but are often adjustable. Speeding up the stalk rolls may be necessary to handle tall stalks with heavy foliage.

The trash knives should be adjusted as close as possible to the stalk rolls without touching them.

Gathering Chains

The gathering chains should run just fast enough to merely guide the stalks into the stalk rolls. The speed of the gathering chains is therefore very important in relation to the ground speed. Normally the speed of the chains are factory pre-set to correspond to a forward ground speed of approximately 5 kilometres per hour (3 mph). If operating at a slower ground speed in lodged corn it may be necessary to slow down the gathering chains. Normally the gathering chain flights should extend slightly beyond the edge of the snapping plates.

Snapping Plates

The spacing between the snapping plates should be as wide as possible without letting an ear pass through. This will result in maximum trash clearance. Use a typical small ear to check this adjustment. The wider clearance at the rear helps to provide adequate stalk clearance. Make sure the snapping plates are centered over the stalk rolls.

CAUTION: Never adjust, repair, or lubricate the corn head or combine while the engine is running.

Ear Savers

Ear savers are available which help prevent loose ears from sliding over the gathering chains to the ground. In down corn if the stalks tend to plug the picking unit, these may be removed.

Cylinder

Use initial cylinder settings specified by the manufacturer. When adjusted properly, the cylinder speed and concave settings should result in few kernels remaining attached to the cob, and the cobs should not be excessively broken. Cylinder speeds between 400 and 700 rpm for a conventional cylinder are normally used. The lower cylinder speeds should be used for lower moisture contents. Running the cylinder too fast results in cracked kernels and excessive fines. The addition of cylinder filler bars is often required to prevent ears from passing through the cylinder unthreshed.

Concave

Concave clearance should be as wide as possible while still getting all kernels from the cob. Too little concave clearance can cause excessive cob breakage, resulting in losses from unshelled corn remaining on broken cobs. Removal of alternate, or even two of three concave wires on small grain concaves should reduce kernel damage and separation losses. A special wide spaced concave is available for some combines.

Rotary Combines

Because of the wide variation in design of rotary combines, recommendations in the operator's manual should be used as an initial setting, and further adjustments made as necessary. Special attachments and adjustments which may be required for corn harvesting will also be outlined in the operator's manual.

Other Accessories

A variety of other special attachments for corn harvesting are available from most manufacturers. Deep-toothed, wide-spaced chaffer sieves have more capacity than regular sieves. Perforated screens in such areas as the elevator doors, clean grain pan, feeder house bottom, and discharge auger help to remove dirt, weed seeds, and fines from the corn. Gathering extensions for the corn head may be helpful in tall crops to prevent loss of ears.

Rear Wheel Weights

In many cases rear wheel weights are required to equalize the weight distribution when attaching the corn head to the combine. Check your operator's manual.

TABLE 4

To measure ear losses use an area of 50 m² (60 yd²).

Length of rows required:

Row Spacing			Length Required	
No. of Rows	centimetres	(in)	metres	(yds)
4	76	(30)	16.5	(18.0)
4	91	(36)	13.7	(15.0)
4	97	(38)	12.9	(14.1)
4	102	(40)	12.2	(13.3)
6	76	(30)	10.9	(11.9)
6	91	(36)	9.1	(9.9)
6	97	(38)	8.6	(9.4)
6	102	(40)	8.2	(8.9)
8	76	(30)	8.2	(8.9)

Procedure

1. Weigh preharvest ear losses in 50 m² (60 yd²) ..... kg (lb)
2. Weigh total ear losses after harvest in 50 m² (60 yd²) ..... kg (lb)
3. Harvesting ear loss (2 minus 1) ..... kg (lb)
4. Multiply the ear loss (kilograms) by 150 to get loss in kilograms per hectare, or multiply the ear loss (lb) by 60 to get loss in lb/acre.

   Note: harvesting ear loss should be about 60 kilograms per hectare (54 lb/acre).

Row Alignment

If possible, match harvest rows to planter rows. Often the row spacing from two adjacent passes of the planter is not uniform, creating problems if these two rows are straddled by the corn header. Concentrate on driving accurately, making sure the header is down and aligned perfectly on new rows after turning at the end of the field.

Forward Speed

A ground speed of approximately 5 kilometres per hour (3 mph) will usually give the least ear loss. The speeds of the stalk rolls and gathering chains are usually set for this forward speed.

Field Losses

Carefull adjustments and harvesting practices are necessary to minimize losses in the field. The loss of each 0.3 kilograms (⅔ lb.) ear in an area of 50 m^2 (60 yd^2) represents a 45 kilogram per hectare (40 lb/ac) grain loss. Further the loss of 40 loose kernels in an area of 1 m^2 (1.2 yd^2) represents a yield loss of 100 kilograms per hectare (90 lb/acre). (Tables 4 and 5)

TABLE 5

To measure kernel losses and cylinder losses use a one square metre (1.2 yd^2) frame.

Width of Frame (equal to row spacing)		Length of Frame Required	
cm	(in)	cm	(in)
102	(40)	98	(39)
97	(38)	103	(41)
91	(36)	110	(43)
76	(30)	131	(52)

Procedure

1. Place the frame over the centre of each row behind the combine and count the loose kernels in the ground inside the frame for each row.

Row	No. of Kernels	Row	No. of Kernels
1	.....	5	.....
2	.....	6	.....
3	.....	7	.....
4	.....	8	.....

Add the kernels from all rows and divide by the number of rows. Then divide by 0.4 to get kilograms per hectare, or divide by 0.45 to get lb/acre.

$$\frac{\text{Total no. of kernels in all rows}}{\text{No. of rows} \times 0.4\ (0.45)} = \text{kilograms per hectare (lb/acre) loss}$$

Kernel loss = ...

2. Repeat step 1 counting the kernels attached to threshed ears to get the cylinder loss.

Cylinder loss = ...

Note: Loose kernel loss should be about 30 kilograms per hectare (27 lb/acre) and cylinder loss should be about 12 kilograms per hectare (11 lb/acre).

Drying and Storage

Drying of the corn is essential when harvesting above 18 percent moisture content unless it is placed in airtight storage, preserved in acid, or frozen. Maximum recommended drying temperatures are 45°C (110°F) if germination is a factor, 60°C (140°F) for distilling, and 90°C (195°F) for feed. Stress cracks and moisture rebound may be a problem due to the large amount of water removed. But, these problems can be reduced by slowing down the drying rate after the corn reaches 18 percent moisture content, using a slower cooling rate, or implementing a combination

system of heating, tempering, and slow cooling, commonly called dryeration. Use of the dryeration process reduces fuel consumption substantially as well as improving the grain quality.

Overhead costs for a grain dryer are frequently greater than the fuel costs, especially when drying relatively small amounts. Due to the cool weather which normally prevails during corn harvesting, the corn can be stored in the damp conditon for a few days before drying. This may allow one dryer to be used by several farmers. Adequate aeration must be provided for corn in temporary damp storage and when stored at above ambient temperatures after drying.

Producers should consult the Agriculture Canada publication #1700 "Heated-Air Grain Dryers" for specific information on drying corn and the need for aeration.

MARKETING AND USE OF GRAIN CORN

Manitoba grown grain corn normally finds a ready market in the distilling industry for beverage alcohol purposes and the feed industry. To date, small amounts have been used for on-farm feeding, although it is expected to increase as larger quantities of grain corn are produced. Manitoba grain corn is also beginning to find its way into off-shore markets.

The distilling industry requires corn of high quality. This usually means that only corn which reaches full maturity in the field can be marketed for distilling purposes. Lower quality corn which fails to meet quality specifications for distilling can be sold to feed mills, feedlot operators, or used for feed on the farm.

The main market for distilling corn in Manitoba is the Seagram Co. Ltd. distillery located at Gimli. Their

The Canadian Grain Commission specifications for official grades of corn are as follows:

GRADES OF CORN (Canada Western)
The class name, whether Yellow, White or Mixed shall be added to and become part of the grade name

	Standard of Quality			Maximum Limits of		
				Damaged Corn		
Grade Name	*Minimum grams/ standard half litre container (as determined at primary elevator)	Minimum Percentage of Variety or type other than for Mixed Corn	Degree of Soundness	Heat Damaged	Total Damaged	Cracked Kernels & Other Foreign Material
No. 1 Canada Western	345	95	Cool and sweet and uniform in size	About 0.1%	3%	About 2%
No. 2 Canada Western	335	95	Cool and sweet	About 0.2%	5%	3%
No. 3 Canada Western	320	95	Cool and sweet	About 0.5%	7%	5%
No. 4 Canada Western	310	95	Cool and sweet	About 1%	10%	7%
No. 5 Canada Western	190	95	Cool, slight odour but not sour or musty	3%	15%	12%

*The official test weight as published by the Canadian Grain Commission is specified as a minimum of 68 kilograms per measured hectolitre for No. 1 Canada Western grade, 66 for No. 2 Canada Western grade, 64 for No. 3 Canada Western grade, 62 for No. 4 Canada Western grade, and 58 for No. 5 Canada Western grade.

quality specifications for an annual requirement of 50 000 tonnes (2 million bu) are as follows:

(1) Minimum bulk density — 70 kilograms per hectolitre

(2) Maximum moisture content — 14 percent
— propane and natural gas fired dryers are recommended with intake air temperature not exceeding 60°C (140°F).

(3) Maximum cracked corn and foreign material — 3 percent

(4) Odour: (i) free from burnt and noxious odours
(ii) oil-dried corn will not be accepted

CORN SILAGE

Corn harvested as whole plant silage is still a practical method of producing feed for beef and dairy herds. As a plant, corn is extremely efficient in the conversion of sunlight to energy. Corn also has the ability to utilize water and nutrient inputs sufficient to allow maximization of an extended growing season.

Because of its high carbohydrate content, corn is a most suitable crop for ensiling. The addition of a feed grade urea supplement mixed in at the time of ensiling, plus minerals, salt and vitamins, allows the production of a complete feed for livestock. The resulting feed is very palatable to cattle; and, if chopped sufficiently fine at the time of harvest is readily accepted by sheep.

Providing the dry matter content of the green forage is above 35 percent at time of ensiling, it will readily meet the dry matter intake requirements of even the highest-producing livestock.

Mechanized silage feeding systems, which save time and labour for the farm operator, are available. Tower silos, with varying unloading systems, are well suited to conveyor chain feeding systems, and particularly useful in a dairy operation. When bunker silos are used, silage may be moved to nearby feeders with a tractor and front end loader, or fed directly from the bunker by using a portable feed gate or electric fence wire. Such methods are popular with beef cattle farmers.

Whole plant corn silage, with necessary supplements, can form an animal's total ration. The leaves and stalks can be equal in energy value to high quality hay. While the grain is exceptionally high in energy, it is low in protein content. Whole plant corn silage contains 65 to 70 percent total digestible nutrients. Most dairymen prefer to feed about 25 percent of some other forage such as alfalfa hay. Corn silage is also an excellent feed for growing beef calves and heifers, as it has satisfactory fattening qualities.

Many hybrid varieties of corn have been developed, each with varying heat unit requirements and yield potential. It is advisable for a producer to study the recommended list of hybrids published annually and to select several cultivars within the probable heat unit expectation for his particular farm location. Harvesting the earliest maturing hybrid first, recording the weight of each hybrid when mature and harvested, extends the harvest period. This allows for the possibility that the later maturing hybrids will yield more forage.

A determination of the dry matter percentage is essential before harvesting each hybrid. Daily composite samples should also be taken as the corn enters the silo. Representative samples of each hybrid should be sent to the feed analysis laboratory for the appropriate analyses.

Nutritional Value of Whole Plant Corn Silage

Silage is an efficient form of storing corn for livestock feed. This is due to the high carbohydrate content of the corn plant which encourages the ensilage process. Further, the use of the entire plant produces one and one-half times the feed nutrients obtained when the crop is harvested as grain. If ensiled at the correct stage of maturity, the ear contributes about 70 percent of the total feeding value of whole silage.

How does whole plant corn silage compare with barley? Under good management, one hectare of land can be expected to produce 2 700 kilograms (5,954 lb.) of barley which at 75 percent T.D.N., contains 2 025 kilograms (4,465 lb.) of digestible nutrients. Under equally good management one hectare of corn harvested as whole plant silage can produce 22 500 kilograms (49,613 lb.) of silage, which at 33 percent dry matter and 60 percent T.D.N. contains 4 455 kilograms (9,823 lb.) of digestible nutrients — more than double the nutrients produced by barley harvested as mature grain.

The mineral content of corn silage is fairly low in comparison to other forage crops. It may also be deficient in certain minor elements such as copper, cobalt, and iodine and Vitamins A and D. Minerals are required for both dairy and beef cattle. Supplement corn silage with calcium, phosphorus, magnesium, sodium, sulphur, and the minor elements plus the vitamins, during the winter feeding period.

When to Ensile

Silage corn should be harvested when the moisture content of the whole plant is between 62 and 70 percent. The ideal moisture content is 65 to 68 percent. At this moisture content the kernels are well dented, glazed in appearance on the cap of the kernel, and the leaves may still have some green colour. Harvesting at moisture levels above 70 percent can cause the silage to turn rancid, resulting in heavy seepage and loss of nutrients. In addition, high moisture silage will probably cause severe feeding difficulties due to freezing, resulting in reduced dry matter intake by animals due to excess moisture. Conversely, harvesting at too low a moisture content can cause difficulties in packing the silage properly, resulting in overheating which reduces the digestibility and produces high dry matter losses.

Table 6 indicates how the feeding value of corn silage increases with advancing maturity. For equal energy intake, it would be necessary for livestock to consume almost twice as much corn silage with 8

percent moisture as compared to silage with 65 percent moisture. Livestock cannot eat enough of the wetter silage to overcome the energy differences.

How to Make Whole Plant Silage

The objective in silage making is the preservation of succulent feed by the development of enough acid to prevent excess fermentation and spoilage. In accomplishing this objective the essential needs are: (1) the exclusion of air and rain water; (2) the presence of sufficient carbohydrate to ensure adequate lactic acid formation.

1. The degree of packing necessary to exclude air depends upon the moisture content of the corn at time of harvest, and the length of cut. In general, the drier the material, the more packing is required. The forage harvester should be set at 6 millimetres (¼ in.) cut for normal conditions. If the silage is getting too dry (less than 60 percent moisture) a shorter cut is desirable, and sufficient water should be added to bring the moisture content to 65 percent. An alternate method is the addition of an organic acid mixture of propionic, acetic or formic acid to prevent mold growth and ensure obtaining a quality product. Bacterial cultures are now on the market which may enhance the fermentation process.
2. Corn is a high carbohydrate material and, therefore, ensiles easily because adequate quantities of desired acids are formed. Corn ensiled at the proper stage of maturity does not require the addition of carbohydrate materials such as small grains for acid formation. For good quality silage, substantial development of grain on the corn ear is required. The higher the ratio of grain to plant, the higher is the concentration of digestible energy (T.D.N.).

On a dry matter basis, silage corn harvested at the full dent stage commonly contains about 8 to 10 percent crude protein. By adding 4 to 5 kilograms per tonne (9 to 11 lb./t) of urea to corn silage at time of ensiling, the crude protein content of corn silage can be increased to 12 or 13 percent. If urea is not added, the ration can be balanced with a protein supplement.

TABLE 6

Effect of Maturity on the Energy and Protein Content of Whole Plant Corn Silage (Unfrosted)

Whole plant moisture %	Descriptive stage	Energy		Protein	
		As-fed basis %	Dry matter basis %	As-fed basis %	Dry matter basis %
80	Milk	12.9	64.5	1.8	9.0
75	Soft dough	16.8	67.2	2.1	8.4
70	Hard Dough	20.8	69.3	2.4	8.0
65	Mature	24.2	69.1	2.8	8.0

*Source — Corn Silages — Publication 92 — Ontario Dept. of Agriculture and Food

Equipment for Silage Corn Harvesting

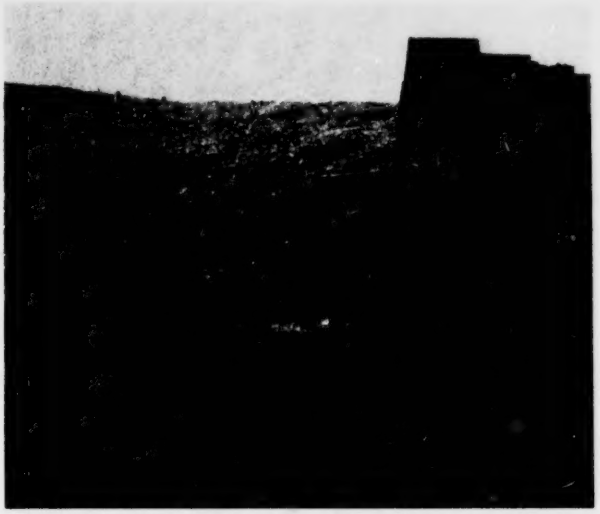
Equipment for harvesting corn silage is basically the same as for harvesting hay or cereal crop silage, except that a corn header instead of a pickup must be used on the forage harvester. In order to get good efficiency, it is essential to have a well matched harvesting system with adequate hauling capacity. A tractor with at least 60 kilowatts (80 H.P.) is needed, and a minimum of two trucks and/or wagons for hauling. For a haul of 1.6 kilometres (1 mi) or less, two large wagons may be adequate. Two trucks with 20 m^3 (26 yd^3) boxes should be adequate for hauls up to 5 or 6 kilometres (3 to 3.6 mi). If tower silos are used for storage, unloading rates are reduced, and extra hauling capacity may be needed. A crew of three or four persons is needed for an efficient operation. A harvesting rate of 5 to 6 tons per hour of dry matter or 16 tons per hour wet silage should be possible with a medium sized harvester and a 70 kilowatt (95 H.P.) tractor. A large harvester with a 100 kilowatt (135 H.P.) or larger tractor could harvest 7 to 10 tons of dry matter per hour.

Urea applicators for adding urea to silage can be mounted on forage harvesters. Good mixing is ensured with this method, and inconvenience is kept to a minimum.

Storage and Handling

Corn silage can be stored in an upright silo, or a horizontal, bunker-type silo. An elaborate silo is not required, but it is desirable to put up some walls to

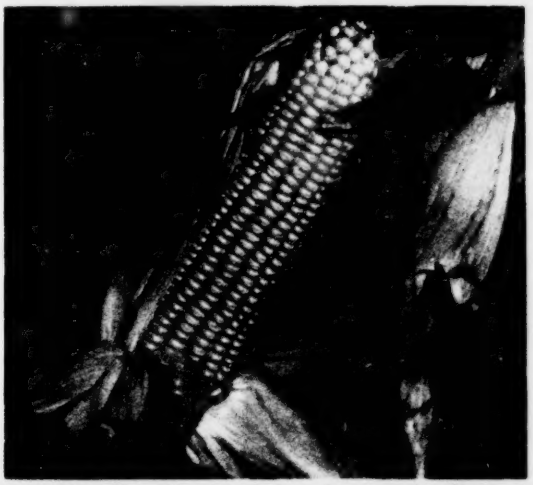
keep the pile from spreading out too far, which aids in packing. In an open silo the corn silage should be covered with plastic as soon as possible after filling to exclude air and rain water. The plastic must be weighted down over its entire area to prevent air from entering.



The horizontal or bunker silo offers an efficient method of storing corn silage.

The location of the silo is an important factor for convenience in winter feeding. Generally, it should be as close as possible to the feeding area so that feed mechanization is possible, keeping feeding time to a minimum. Front end loaders with buckets are commonly used to remove silage from horizontal silos. If the feeding area is nearby, no extra hauling equipment and very little time is required.

Additional detailed information on silage harvesting procedures, silo wall designs, construction specifications, silo sizing, sealing, and self feeding is available from the Engineering Section of Manitoba Agriculture.



Corn matured to the hard dough or early glaze stage (65 to 68 percent whole plant moisture) has reached the ideal stage for harvest as whole plant silage.

FEEDING CORN TO LIVESTOCK

Corn is an excellent feed for both dairy and beef cattle. The grain is exceptionally high in available energy, low in protein and, under most feeding conditions, exceptionally palatable. Several different ways that corn can be used for feed are as follows:

Corn Grain

Corn on a net energy basis is worth up to 12 percent more than barley for milk production and fattening cattle. Corn grain should be coarsely ground or rolled before feeding, since cattle cannot efficiently digest the whole grain. A fine grind is not necessary and may, in fact, be detrimental.

The crude protein (CP) content of corn grown in Manitoba on an 'as fed' basis ranges from 7.5 to 10.5 percent in contrast to 9 to 12 percent for barley. In many rations corn will require a protein supplement in relation to its energy concentration, whereas barley may not. Soybean meal, canola meal, urea or other protein sources can be used to meet the protein deficit. Urea should not make up over one percent (10 kilograms urea per 1000 kg, or 10 lb urea per 1000 lb concentrate) of the dairy concentrate if high levels of grain consumption are desired. Dairy cows in early lactation may not make efficient use of urea.

Urea is relatively unpalatable and at high levels is toxic, consequently, it should be well mixed with the other ingredients. As a rule of thumb, if 0.5 kilograms (1.1 lb) of urea plus 3 kilograms (6.6 lb) of corn costs less than 3.5 kilograms (7.7 lb) of soybean meal (44 to 49 percent CP), then a grain ration can be made up more economically by using urea as the 'protein' supplement up to the limit suggested. Sample dairy cattle rations using corn are given in Table 7. Sample rations for beef cattle can be found in Table 8. Changing from an alfalfa forage and a barley based concentrate mixture feeding program to that of corn silage and/or corn grain may require major changes in protein and mineral supplementation of diets. Your feed manufacturer, Agricultural Representative or the Manitoba Agriculture Feed Analysis Service could help you make the necessary adjustments.

Corn is an excellent high energy food for poultry and swine. For these animals the quantities used to balance and formulate the ration will depend partly on the protein content of the corn. Corn and wheat are somewhat comparable in their contribution to rations for these animals, except in protein content, which is usually lower in corn by 2 to 5 percent. Both of these grains, as well as barley, require supplementation to provide a balance of amino acids and minerals suitable for swine and poultry.

Whole Plant Corn Silage

Corn silage should contain some grain. The concentration of digestible energy or TDN in silage depends on the ear to stem and leaf ratio. On a dry matter basis, when the grain is removed corn silage has TDN content of approximately 55 to 60 percent, whereas corn silage with the grain contains 60 to 68 percent TDN. However, the concentration of digest-

ible energy in the corn plant of a specific variety may not change a great deal from soft dough to th dent stage of maturity.

High quality corn silage (well matured with 32 to 38 percent dry matter) makes an excellent feed for dairy and beef cattle, and also enables high energy yields per acre to be realized. Up to 75 percent of roughage in a dairy ration for lactating cows can be made up of corn silage. In fact some dairymen feed corn silage as the only source of roughage.

Rations for growing beef cattle may be made up wholly of corn silage plus a protein-mineral-vitamin supplement. Rations containing good corn silage (well matured with 35 percent dry matter, properly matured corn contains 30 to 50 percent grain) are also quite satisfactory for fattening beef cattle. Urea can be added to corn silage with a moisture content of 60 to 70 percent at the rate of 4 to 5 kilograms per tonne (8 to 10 lb/t) of green material. With the added urea the treated silage should contain 12 to 13 percent crude protein on a dry matter basis. Corn silage is low in calcium, phosphorus and may be low in magnesium. Thus supplemental calcium, phosphorus and magnesium may be required in rations containing corn silages. Also sulphur may be required when urea is used in place of vegetable protein.

Although corn silage may contain significant quantities of carotene, the use of this carotene by cattle is low, and rations containing high levels of corn silage must be supplemented with vitamin A (15,000 to 20,000 International Units per day for beef and 25,000 to 30,000 International Units per day for dairy cows).

Green Chop and Zero Grazing

Corn can also be harvested as green chop or zero grazed to supplement pasture. It serves this purpose very well, but the energy yield per hectare will be less than when the corn is harvested at a later stage of maturity.

TABLE 7

Sample grain rations for dairy cows making use of grain corn[1]

Ingredients[2]	16% Protein					14% Protein		
	A	B	C	D	E	F	G	H
			kg/t or	(lb/t)				
Corn	614(1354)	615(1356)	800(1764)	760(1676)	342(754)	407(897)	422(931)	757(1669)
Oats	100(221)	100(221)						100(221)
Barley					400(882)		400(882)	
Soybean Meal (44%)				208(459)				
Canola Meal	258(569)				229(505)	164(362)		
Dairy Cattle Supp (35% CP)[3]		285(569)					178(393)	
Dairy Cattle Supp (44% CP)[3]			200(442)					143(315)
Dicalcium Phospate	8(18)			16(35)	8(18)	8(18)		
G. Limestone	10(22)			6(13)	11(24)	11(24)		
Trace mineral salt	10(22)			10(22)	10(22)	10(22)		

1. If good quality legume hay is fed, a 12 to 14 percent crude protein dairy mix may be adequate; however, if grass hay or corn silage without added urea makes up the roughage portion of the ration then a 14 to 20 percent CP concentrate may be required. The total ration on a 90 percent dry matter basis, including all feeds, should contain 12 percent CP for less than 15 kilograms (33 lb) of milk. 13 percent for 15 to 20 kilograms (33 to 44 lb), 14 percent for 20 to 30 kilograms (44 to 66 lb.) and 15 percent for over 30 kilograms (66 lb). Your cereal grains may be higher or lower in protein than average. Protein levels should be determined by a feed analysis.
2. If 7 kilograms (15.4 lb) of good quality hay or 4.5 kilograms (10 lb) of grass silage is fed, Vitamin A supplementation may not be necessary. However, 2 to 4 million I.U. of Vitamin A can be added per tonne of grain mix at little cost.
3. Dairy cattle supplements containing protein, minerals and Vitamins may be purchased from a feed manufacturer.

TABLE 8

Sample grain rations for Fattening Beef Cattle making use of grain corn

Ingredients	A	B	C	D	E
	Kilograms per tonne (lb/t)				
Corn and Cob Meal			810(1786)		
Corn	800(1764)				500(1103)
Corn Silage		400(882)		400(882)	
Oats				300(662)	315(695)
Barley		540(1191)		250(551)	
Soybean Meal	65(143)	45(99)		40(88)	
Rapeseed Meal			175(386)		70(154)
Hay (alfalfa-brome)	120(265)				100(221)
Minerals	15(33)	15(33)	15(33)	10(22)	15(33)

The protein, minerals and vitamins can be purchased as a supplement from a feed manufacturer. All these rations should be supplemented with Vitamin A.

Corn for Pigs

In North America, if not in most of the world, corn is the most common grain used for feeding pigs. In Canada, pig feeding from Ontario east is based on corn as the primary energy source. In 1981, grain corn became a significant feed grain for Manitoba pigs with a final estimate of some 432 000 tonnes (17,000,000 bu) being grown. This amount of corn properly supplemented and fed only to pigs would have fed out an estimated 1.2 million pigs in Manitoba — our actual market pig production in 1981.

Corn is low in protein and requires more supplemental protein than our traditional feed grain barley. As a guideline some rations with corn as the only grain are given in Table 9. In 1982, in three separate trials, Manitoba corn was fed to growing and finishing pigs at the University of Manitoba and the corn fed pigs had excellent gains and feed efficiency.

TABLE 9

Starter, Grower and Finisher Ration for Pigs.

Ingredient (%)	Starter	Grower	Finisher
Corn	71.0	76.0	83.5
Canola meal (37%)		10.0	14.0
Soybean meal (44%)		11.0	
Supplement (40%)	29.0		
Premix		3.0	2.5
	100.0	100.0	100.0

The rapid gains did result in somewhat fatter pigs (lower index) which would be largely compensated for by less labour and some lower variable and fixed costs.

Since the large 1981 crop was analyzed for protein content, it was decided to analyze approximately 50 samples for amino acid content. The amino acid data are given in Table 10. The data show that lysine, methionine and tryptophan in the 1981 crop were within or exceeded the range of (NRC) values given. The level of threonine is lower than the (NRC) value given. Calculations show that using the recommended levels of supplement or protein sources with corn would more than supply enough of this amino acid to meet the requirements.

TABLE 10

Content of Selected Essential Amino Acids in Manitoba Corn (1981 Crop) In Comparison to NRC — Feed Composition Values.

Lysine	.27	.24[1]-.25[2]
Methionine -cystine	.40	.40[1]-.39[2]
Threonine	.25	.39[1]-.35[2]
Tryptophan	.06	.05[1]-.08[2]
Protein	8.5	8.8[1,2]

1. Nutrient Requirements of Swine (NRC) - 1979.
2. U.S. - Can. Tables of Feed Composition (NRC) - 1982.

VALUATION OF CORN SILAGE, CORN STOVER AND HIGH MOISTURE GRAINS

Corn Silage

METHOD 1: Purchasing corn silage, delivered to a feedlot.

$$\frac{65 \times \text{market price per bu. of corn}}{12} \times \frac{\text{DM \% silage}}{35\%} = \text{Price of corn silage}$$

Example: Corn grain @ $3.50/bu $\frac{65 \times \$3.50/bu}{12} \times \frac{35\%\ DM\ silage}{35\%\ DM} = \$18.96/ton$ of 35% DM

Note: This is the price per ton delivered, price in the field would be less harvesting and hauling costs.

METHOD 2: Value of corn grain × bushels of grain/ton wet silage = Value of 35% DM Corn silage
Grain/ton of wet silage: 5 bushels for a 75 bushel grain crop
6.7 bushels for a 100 bushel grain crop
7 bushels for a 120 bushel grain crop

Example: 5 bu. × $3.50/bu = $17.50/ton 35% DM corn silage

METHOD 3: Value corn silage on dry matter compared to dry matter of alfalfa hay.

Example: If alfalfa hay 85% DM is worth $60/ton ($70/ton DM), therefore corn silage is valued @ $70/ton DM or at 35% DM corn silage = $24.50/ton.

Dry Matter Conversion for High Moisture Grain

METHOD 1: To determine value of high moisture grains: weight of H.M. corn × conversion factor at % moisture = weight at 15.5% moisture.

% Kernel Moisture	Conversion Factor	% Kernel Moisture	Conversion Factor
20	.946	30	.828
22	.923	32	.805
24	.899	34	.781
26	.876	36	.757
28	.852	38	.734

Example: What is the value of corn at 28% if corn at 15.5% moisture is worth $3.50/bu?

$$\frac{\text{(Conversion factor @ 28\%) } 0.852}{\text{bushel wt. of corn } 56} \times \text{price/bu (3.50)} = .053¢/lb.$$

Note: Corn at 15.5% moisture = 3.50 ÷ 56 = .062¢/lb.

METHOD 2: "Rule of thumb" price/bushel − 20% − drying cost = value

Example: 3.50 − 20% (70¢) − 30¢(?) = $2.50.

Value of Corn Stover

	DM%	Protein %	Fibre %	Ca %	Phos %	TDN %
Corn Stover (Silage)	27	7	32	0.38	0.19	58
Oat Hay	88	9	31	0.26	0.24	61
Barley Hay	87	9	26	0.21	0.30	57
Sorghum	90	7	27	0.62	0.19	58
Alfalfa Hay	84	19	28	1.25	0.23	59
Alfalfa-Brome	55	14	34	1.52	0.35	54

Yield of Corn Stover

A corn crop that yields 4.7 tonnes per hectare (75 bu/acre) of grain corn, will leave about 4.5 tonnes per hectare (2 tons/acre) of stover material in the field. Field losses in the harvest operation can be expected to reduce the actual harvest of corn stover to 2.2 - 3.1 tonnes per hectare (1 - 1.4 tons/acre).

The moisture content of corn stover is 70 to 75 percent when the black layer develops in the kernel.

COST OF CORN PRODUCTION

The preceeding sections of this publication show that corn requires a high level of technology in comparison to other grain crops commonly grown. It follows that production costs will be higher. These additional costs are offset by high yield potential which is reached only through adequate inputs of all the key factors. Among the most important factors to consider are: selecting hybrids adapted to the area and using enough seed to establish a good, uniform stand; using adequate amounts of fertilizer to the right formulation as indicated by soil tests; providing effective weed control to deal with the species present, and providing the essential specialized machinery to carry out the necessary operations effectively and on time.

It is important that the grower (or potential grower) has a reasonably accurate picture of the costs involved in corn production. Since the price of specific inputs change from year to year, a statement of average or current figures will not be included, as it can be deceiving. However, an estimate of the higher cost of corn production expressed on a percentage basis in relation to the cost of barley production, is included in the following paragraphs.

Production costs divide into operating costs and fixed costs. The operating costs for corn production are estimated to be about 95 percent higher than the operating costs for barley production. The main items making up the higher operating costs are seed cost, fertilizer input, chemical weed control, and the cost of drying grain corn. The fixed costs for corn production are estimated as being approximately 25 percent higher than for barley production. These additional fixed costs are mainly due to higher land values in the areas best suited for corn production, higher machinery investment and operating costs, and larger storage costs.

These additional costs in corn production are offset by higher yield potential of corn. In comparing the average yield of grain corn and barley in Manitoba during recent years, corn displays a yield advantage of approximately 60 percent.

When corn is grown for silage production, hauling, packing, and the addition of urea or other additives, are other costs that must be added.

For detailed information on the estimated production cost of a wide range of crops, growers should obtain a copy of "Farm Planning and Organization — Crop Planning Guide" prepared annually by the Farm Management Section of Manitoba Agriculture.

METRIC CONVERSION FACTORS

WEIGHT
1 oz = 28.35 g
1 lb = 0.4536 kg
1 ton = 0.907 t

AREA
1 acre = 0.4047 ha
1 sq in = 6.452 cm^2
1 sq ft = 0.093 m^2
1 sq yd = 0.836 m^2
1 sq mile = 2.59 km^2

VOLUME
1 fl oz = 28.41 mL
1 pint = 0.568 L
1 quart = 1.137 L
1 gal = 4.546 L
1 US gal = 3.785 L
1 cu in = 16.387 cm^3
1 cu ft = 0.028 m^3
1 cu yd = 0.765 m^3

LENGTH
1 in = 2.54 cm
1 ft = 0.3048 m
1 yd = 0.9144 m
1 rod = 5.029 m
1 mile = 1.609 km

TEMPERATURE
°C = 5/9 (°F − 32)

PROPORTION
1 fl oz/acre = 70.21 mL/ha
1 lb/acre = 1.121 kg/ha
1 oz/acre = 70.06 g/ha
1 pint/acre = 1.40 L/ha
1 qt/acre = 2.81 L/ha
1 gal/acre = 11.23 L/ha
1 lb/in^2 (psi) = 6.895 kPa
1 ton/acre = 2.24 t/ha

POWER
1 HP = 0.7457 kW
1 HP/ft = 2.45 kW/m

POOR

QUALITY

ORIGINAL